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**State of California  
The Resources Agency  
Department of Water Resources**

**MATRIX OF LIFE HISTORY AND  
HABITAT REQUIREMENTS FOR  
FEATHER RIVER FISH SPECIES  
SP-F3.2 TASK 2**

**COHO SALMON**

**Oroville Facilities Relicensing  
FERC Project No. 2100**



**APRIL 2004**

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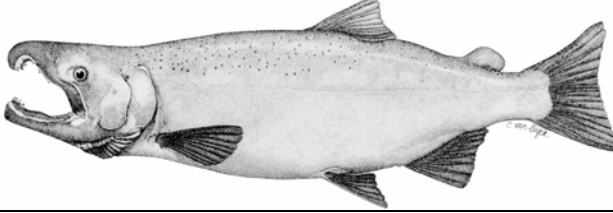
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Matrix Of Life History and Habitat Requirements for Feather River Fish Species – Coho Salmon  
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Element	Element Descriptor	General	Feather River Specific
<b>General</b>			
Common name (s)	English name fishers and laypeople commonly refer to. (e.g., Sacramento pikeminnow)	Coho salmon. Silver salmon is a common name often used in California, but coho salmon has gained wide usage and is the name adopted by the American Fisheries Society (Moyle 2002).	
Scientific name (s)	Latin name (e.g., <i>Ptychocheilus grandis</i> for Sacramento pikeminnow)	The scientific name of coho salmon is <i>Oncorhynchus kisutch</i> (Moyle 2002).	
Taxonomy (family)	Indicate what family they belong to, (e.g., sunfishes, bass, crappies, salmonids etc); also indicate the scientific family name, (e.g., <i>Centrarchidae</i> for sunfish family)	Coho salmon belong to the <i>Salmonidae</i> family (Moyle 2002).	
Picture	Illustration, drawing or photograph.		
Range/location	Broad geographic distribution, where they currently occur (e.g., Gulf of Alaska to Baja California).	The distribution of coho reportedly extends from northern Japan through Kamchatka, across the Bering Sea to Alaska, and south through all coastal areas to California (Sandercock 1991).  In North America, coho salmon reportedly historically spawned in most coastal streams from central California to the Kukpuk River near Point Hope, Alaska (Moyle 2002; Sandercock 1991).	In California, spawning populations were reportedly once found in most coastal streams from the Smith River (Del Norte County) south to the San Lorenzo River (Santa Cruz County), with individual fish straying as far south as the Big Sur River. Today the southernmost populations reportedly are found in Scott and Waddell Creeks (Santa Cruz County), although a small run is maintained in the San Lorenzo River by artificial propagation (Moyle 2002; Sandercock 1991).
Native or introduced	If introduced indicate from where, how and when.	Coho salmon are native to California (Moyle 2002).	
ESA listing status	Following the categories according to California Code of Regulations and the Federal Register, indicate	NOAA Fisheries identified six Evolutionarily Significant Units (ESU) of coho salmon in Washington, Oregon, and California:	Of the six coho salmon ESUs, two are relevant to California: 1) Central California coast. The

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Element	Element Descriptor	General	Feather River Specific
	whether: SE = State-listed Endangered; ST =State-listed Threatened; FE = Federally listed Endangered; FT = Federally-listed Threatened; SCE = State Candidate (Endangered); SCT = State candidate (Threatened); FPE = Federally proposed (Endangered); FPT = Federally proposed (Threatened); FPD = Federally proposed (Delisting), and the date of listing; or N = not listed.	1) Central California coast ESU; 2) Southern Oregon/northern California coasts ESU; 3) Oregon Coast ESU; 4) Lower Columbia River/southwest Washington coast ESU; 5) Olympic Peninsula; and 6) Puget Sound/Strait of Georgia (Weitkamp et al. 1995).	geographic boundaries of this ESU reportedly extend from Punta Gorda in northern California south to and including the San Lorenzo River in central California, and include tributaries to San Francisco Bay, excluding the Sacramento-San Joaquin River system. 2) Southern Oregon/northern California coast. This ESU reportedly includes coho salmon from Cape Blanco in southern Oregon to Punta Gorda in northern California. (Moyle 2002; Weitkamp et al. 1995).  The Central California Coast ESU was listed as <b>SE</b> on 12-31-95, and as <b>FT</b> on 12-2-96. The State listing is limited to the coho salmon populations south of San Francisco Bay. The Federal listing is limited to naturally spawning populations in streams between Punta Gorda, Humboldt County, and the San Lorenzo River, Santa Cruz Co, (DFG 2002a).  SC ( <b>State Candidate</b> ). On 4-27- 01, a petition was filed to include coho from San Francisco north to the Oregon Border. The state petition includes the San Francisco portion of the federal Central California ESU and the northern California portion of the federal southern Oregon/Northern

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			California ESU (DFG 2002a).  The southern Oregon/northern California coast ESU was listed as <b>FT</b> on 6-5-97. The final designation of Critical Habitat was dated 3-17-00. The effected populations are those occurring between Cape Blanco, Oregon and Punta Gorda, California (DFG 2002a).
Species status	Indicate following Moyle's category. If native, whether: Extinct/extirpated; Threatened or Endangered; Special concern; Watch list; Stable or increasing. If introduced, whether: Extirpated (failed introduction); Small highly localized; Localized; Widespread and stable; Widespread and expanding.	Moyle (2002) classifies the coho salmon in California as "threatened/endangered".	
Economic or recreational value	Indicate whether target species for food or trophy. Whether desirable by recreational fishers or commercial fishers, or both.	Coho salmon reportedly supports valuable commercial and sport fisheries in the Pacific Southwest Region. According to the Pacific Fishery Management Council (PFMC), the sport fishery accounted for 58% of the total catch of coho salmon along the California coast in 1985 (Hassler 1987).	
Warmwater or coldwater	Warmwater if optimum temperature range similar to basses; coldwater if optimum temperature range similar to salmonids and trout.	Coho salmon are a coldwater species (Moyle 2002).	
Pelagic or littoral	Environment: Pelagic - living at the surface of the ocean far from shore (e.g., growing and non-spawning adult salmon). Littoral - living near the shore.	California coho salmon reportedly may not move far in the ocean. Coho salmon reportedly stay in the upwelling system of the California coast which provides high densities of food and cold water temperatures (Moyle 2002).  Along the California coast, coho salmon probably remain within the limits of the continental shelf or within about 160 km from shore (Shapovalov and	

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Element	Element Descriptor	General	Feather River Specific
		Taft 1954).  Coho salmon and fry reportedly occupy the littoral zone but do not make extensive use of the pelagic zone (Bryant et al. 1996).	
Bottom or water column distribution	Environment: bottom (benthic) or along water column	In California streams, coho salmon reportedly live near the stream surface (Hassler 1987).  Within the streams on Prince of Whales Island, Alaska, coho salmon reportedly used specific midwater locations with age 1 + coho salmon occupying sites in deeper water (Dolloff and Reeves 1990).	
Lentic or lotic	Environment: lentic, pertaining to stagnant water (or lake-like); lotic, to moving water (or river-like).	Although juvenile coho salmon are commonly associated with stream systems, they reportedly will use ponds and lakes for rearing (Bryant et al. 1996).	
<b>Adults</b>			
Life span	Maximum age they can attain. Average age of the old fishes.	California coho salmon generally have a 3-year life-cycle, with reportedly about half spent in fresh water and half spent in salt water. Jack males reportedly are 2 years old (Moyle 2002).  A number of male coho salmon reportedly mature at about two years (and at about 2 lbs). In California, nearly all coho salmon that do not mature at two years, reportedly mature at the end of their third year. The few four-year old coho salmon are fish that spent their first two years in fresh water (Fry 1973).	
Adult length/age	Indicate: Length and weight at which they first spawn or reproduce; average length and maximum length (or weight) the fish can attain. Also, growth characteristics.	Coho salmon are fairly large salmon, with spawning adults reportedly attaining 21.7 to 30.3 inches (55 to 77 centimeters) FL (Moyle 2002).  Young coho salmon reportedly grow 1.1-1.5 mm/day, reaching 15.7 to 19.7 inches (40 to 50 centimeters) FL in their first year at sea. They reportedly return to spawn after 16 to 18 months at sea at 23.6 to 31.5 inches (60 to 80 centimeters) FL. The returning jacks reportedly measure about 15.7 inches (40 centimeters) FL. (Moyle 2002).	

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Element	Element Descriptor	General	Feather River Specific
		<p>In California, coho salmon reportedly average 16 inches (40.6 centimeters) at age 1/1 (all males), 25.5 inches (64.7 centimeters) at age 1/2 (males), and 25.2 inches (63.9 centimeters) at age 1/2 (females) when they return to freshwater to spawn (Shapovalov and Taft 1954).</p> <p>The reported range of mean spawner size of coho salmon in California streams is 2.5 to 3.0 inches (6.3 to 7.6 centimeters) (Weitkamp et al. 1995).</p>	
Adult weight	Indicate: Weight at which they first spawn or reproduce; average weight; and maximum weight the fish can attain.	<p>Migrating and spawning coho salmon adults reportedly typically weigh between 6.6 to 13.2 pounds (3 to 6 kilograms). (Moyle 2002).</p> <p>The average weight of coho salmon at spawning time reportedly is 7 to 12 pounds (3.2 to 5.4 kilograms) and individuals over 15 pounds (6.8 kilograms) reportedly are uncommon (Fry 1973).</p>	
Physical morphology	General shape of the fish: elongated, fusiform, round, etc.	Coho salmon have fusiform (streamlined) bodies (Moyle 2002).	
Coloring	Indicate color, and color changes, if any, during reproduction phase.	<p>Coho salmon captured at sea or shortly after entry into freshwater are mostly silver-colored on their sides and ventral surfaces. The dorsal surface is a dark metallic blue and there are irregular black spots on the back and the upper lobe of the caudal fin (Fry 1973; Sandercock 1991).</p> <p>Spawning coho salmon males are typically intensely dark red on the sides, with the head and back dark green and the belly gray to black. Females are drabber and paler than males, often appearing a dull, dark pink on the sides (Moyle 2002).</p>	
Other physical adult descriptors	Unique physical features for easy identification.	Strongly hooked jaws and slightly humped backs characterize coho salmon spawning males. The jaw is less strongly hooked in jack males and is only slightly hooked in females. Both sexes have small black spots on the back, dorsal fin and upper lobe of the caudal fin, with no spots on the lower lobe of the caudal fin (Moyle 2002).	

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		The presence of black spots on the back, dorsal fin, and upper lobe of tail will separate coho from chum and sockeye salmon (Fry 1973).	
Adult food base	Indicate primary diet components, i.e. what they eat.	Oceanic coho salmon reportedly feed on a wide variety of small pelagic marine fishes. Shrimp, crabs, and other pelagic invertebrates also reportedly constitute an important component of their diet (Moyle 2002).	
Adult feeding habits	Indicate: Plankton eater, bottom feeders, piscivorous, active hunters, ambush predators, filter feeders. Night, day, dusk or dawn feeders.	Oceanic coho salmon reportedly become increasingly piscivorous as they increase in size, feeding voraciously on a wide variety of small pelagic marine fishes (Moyle 2002).	
Adult in-ocean residence time	For anadromous species, age when they migrate to the ocean and duration spent in the ocean before returning to freshwater to spawn.	Coho salmon reportedly remain at sea for 16 to 18 months before returning to freshwater to spawn. Some males reportedly return as "jacks" after 6 months at sea (Moyle 2002).	
Adult habitat characteristics in-ocean	For anadromous species, description of the ocean habitat: along major current systems, gyres, pelagic (beyond continental shelves) and neritic (above continental shelves) zones, etc.	California coho salmon reportedly may not move far in the ocean. They reportedly stay in the upwelling system of the California coast which provides high densities of food and cold water temperatures (Moyle 2002).	
<b>Adult Up Migration (Immigration)</b>			
Range of adult upstream migration timing	Time of year adults migrate upstream (e.g., Feb - Aug). If applicable, indicate for both spring and fall runs.	<p>In the short coastal streams of California, most coho salmon reportedly return during mid-November through mid-January (Moyle 2002).</p> <p>Over the range of the species, spawning runs of coho salmon reportedly enter streams within the period of September through March (Shapovalov and Taft 1954).</p> <p>In Scott and Waddell creeks of Santa Cruz County, spawning migrations of coho salmon reportedly often do not occur until November or December (Shapovalov and Taft 1954).</p>	
Peak adult upstream migration timing	Time of year most adults migrate upstream (e.g., April-May). If applicable, indicate for both spring	Spawning migrations of coho salmon reportedly usually peaks in December and January (Shapovalov and Taft 1954).	

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Element	Element Descriptor	General	Feather River Specific
	and fall runs.		
Adult upstream migration temperature tolerances	Temperature extremes upstream migrating adults can survive. Indicate whether these are stress or lethal levels (e.g., 48°–68°F or 8.9°C–20°C)	In California, coho salmon reportedly usually migrate upstream when water temperatures are 39.2°F to 57.2°F (4°C to 14°C) (Shapovalov and Taft 1954).	
Adult upstream migration temperature preferences	Optimum temperature range of upstream migrating adults for growth and reproduction (e.g., 50°F–58°F or 10°C–14.4°C).	Reiser and Bjornn (1979) indicated that coho salmon migration reportedly normally occurs when water temperature is in the 44.6°F to 60.8°F (7°C to 16°C) range.	
<b>Adult Holding (Freshwater)</b>			
Water temperature range for holding adults	Temperature extremes fish can survive. Indicate whether these are stress or lethal levels.	<p>Coho salmon from central California enter rivers in late December or January, and reportedly spawn immediately afterwards (Weitkamp et al. 1995). There is very limited information on the habitat requirements of coho salmon during adult holding, partially because coho salmon spawn immediately after immigration to spawning grounds (Weitkamp et al. 1995).</p> <p>In California streams, adult coho salmon are reportedly found in water temperatures ranging from 45°F to 60.1°F (7.2°C to 15. 6°C) (Hassler 1987).</p> <p>Adult coho salmon were reportedly found in a British Columbia stream at water temperature ranges of 33.8°F to 68°F (1°C to 20°C) (Fausch and Northcote 1992).</p>	
Water temperature preference for holding adults	Optimum temperature range of fishes for growth and reproduction.	<p>In California streams, adult coho salmon reportedly prefer water temperatures within the range of 53.2°F to 58.3°F (11.8°C to 14.6°C) (Hassler 1987).</p> <p>Within a British Columbia stream, the majority of adult coho salmon were reportedly found at water temperatures ranging from 46.4°F to 51.8°F (8°C to 11°C) (Fausch and Northcote 1992).</p>	
Water depth range for holding adults	Vertical distribution, depth range along the water column (e.g., 6–20 ft or 1.8–6.1 m).	The minimum water depth that adult coho salmon were found in California streams reportedly was 0.6 feet (0.18 meters) (Hassler 1987).	

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		The water depth range where adult coho salmon were found in a British Columbia stream reportedly ranged from 1.9 to 7.9 inches (4.8 to 20 centimeters) (Fausch and Northcote 1992).	
Water depth preference for holding adults	Optimum water depth range (e.g., 10–12 ft or 3.04–3.7 m).		
Substrate preference for holding adults	If bottom dwellers, indicate substrate: mud, sand, gravel, boulders, aquatic plant beds, etc. If gravel, indicate average size of gravel preference (e.g., 0.08–0.3 inch or 2-8 mm diameter).		
Velocity range for holding adults	Minimum and maximum speed of water current (flow) the fish can tolerate (e.g., 4–8 ft/sec or 1.21–2.4 m/sec).	Adult coho salmon reportedly utilize water velocity ranges of 3.4 to 10.6 ft/sec (1.04 to 3.23 m/sec); the maximum water velocity adults can tolerate reportedly is 8 ft/sec (2.44 m/sec) (Hassler 1987).  Within a British Columbia stream, the water velocity where adult coho salmon were found reportedly ranged from 0.0007 to 21.3 ft <sup>3</sup> /sec (0.0002 to 6.5 m <sup>3</sup> /sec) (Fausch and Northcote 1992).	
Velocity preference for holding adults	Preferred water current speed or flow velocity (e.g., 6-7 ft/sec or 1.8–2.1 m/sec).	Over 85% of coho salmon in the streams on Prince of Whales Island, Alaska occupied focal points where water velocity reportedly was between 0.0 to 3.5 in/sec (0.0 to 9.0 centimeters/sec) (Dolloff and Reeves 1990).	
Other habitat characteristics for holding adults	General description of habitat (e.g., turbid or clear waters, still or with water currents, presence of aquatic plant beds, plant debris etc.).	Migrating coho salmon reportedly require deep and frequent pools for resting and to escape from shallow riffles where they are susceptible to predation. Large wooden debris (LWD) and other natural structures such as large boulders, riparian vegetations, and undercut banks reportedly provide cover from terrestrial predators in shallow areas (DFG 2002b).	
Timing range for adult holding	Time of year (earliest-latest) and duration of stay from upstream migration to spawning.	The first adult coho salmon was reportedly observed in mid-September and the last fish was seen in mid-December within Carnation Creek (Holtby et al. 1989).	
Timing peak for adult	Time of year when maximum	Coho salmon spawning occurred several weeks	

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holding	number of adults are present before spawning.	after entry into Carnation Creek (i.e., mid-September to mid-December) (Holtby et al. 1989).	
<b>Spawning</b>			
Fecundity	Average number of eggs females lay in a spawning season.	Each female coho salmon reportedly lays 1,400 to 3,000 eggs. California coho salmon reportedly have lower fecundities than the more northern coho populations (Moyle 2002).  Shapovalov and Taft (1954) developed the following empirical fecundity formula for coho salmon; the number of eggs as a function of fork length (FL): number of eggs = $0.01153 \times FL^{2.9403}$	
Nest construction	Location and general description of nest -- substrates, aquatic plants, excavations, crevices, redds.	Female coho salmon reportedly choose nesting sites in gravel deposits at the lower end of pools just above a riffle (Shapovalov and Taft 1954).  On the spawning grounds, coho salmon reportedly seek out sites of groundwater seepage and favor areas where the stream velocity is 0.98 to 1.8 ft/sec (0.3 to 0.5 m/sec). The female generally selects a redd site at the tail-out of a pool or head of a riffle area where there is good circulation of oxygenated water through the gravel (DFG 2002b).	
Nest size	Average number of fertilized eggs in nest, range size and average dimension of the nest.	A completed coho salmon redd, containing several nests, reportedly covers an area of 5.6 to 17.1 ft <sup>2</sup> (1.7 to 5.2 m <sup>2</sup> ) (Hassler 1987).  A pair of spawning coho salmon reportedly requires about 126 square feet (38.4 square meters) for redd and inter-redd space (DFG 2002b).	
Spawning process - broadcast, etc	Broadcast spawners are fish, which release their gametes into the water, where fertilization may occur. Or whether females give live births.	Coho salmon are broadcast spawners. Females reportedly typically choose a spawning site near the head of a riffle, just below a pool, where water changes from smooth to turbulent flow. Each female reportedly builds a succession of redds in the same place, moving upstream as she deposits a few hundred eggs in each redd. Spawning reportedly takes about a week to complete (Moyle 2002).  Female coho salmon reportedly may guard the nest	

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		for up to two weeks or until they become too weak to maintain a position against the current (Hassler 1987).	
Spawning substrate size/characteristics - range	Range of substrates used during spawning (e.g., mud, sand, gravel, boulders, beds of aquatic plants). Indicate presence of plant/wood debris, crevices at spawning sites. If gravel, indicate average size (e.g., 0.79–1.6 inches or 2–4 centimeters).	About 85% of coho salmon redds reportedly occur in areas where the substrate is comprised of gravel 5.9 inches (15 centimeters) diameter or smaller (DFG 2002b).	
Preferred spawning substrate	Indicate preferred spawning substrate (e.g., mud, sand, gravel, boulders, plant bed, etc.).	Reiser and Bjornn (1979) reported that gravel 0.5 to 4.0 inches (1.3 to 10.2 centimeters) in diameter was acceptable as coho salmon spawning substrate.  Spawning coho salmon in the Trinity River, California reportedly preferred gravel of 3.0 to 5.9 inches (7.5 to 15.0 centimeters) in diameter (Hassler 1987).	
Water temperature range for spawning	Documented temperature range the fish can spawn.	Coho salmon reportedly spawn in riffles at water temperatures of 42.8°F to 53.6°F (6°C to 12 °C) (Hassler 1987).	
Water temperature preference for spawning	Range of optimal temperature for spawning.	Bjornn and Reiser (1991) reported that the suitable water temperature range for spawning coho salmon is 39.2°F to 48.2°F (4°C to 9°C).	
Velocity range for spawning	Minimum and maximum speed of water current the spawning fish can tolerate.	In California, coho salmon reportedly spawn in water moving at velocities of 0.6 to 2.5 ft/sec (0.18-0.76 m/sec) (Hassler 1987).	
Velocity preference for spawning	Preferred water current (flow velocity) during spawning.	Coho salmon reportedly spawn mostly in small streams where flow is 2.9 to 3.4 cfs (DFG 2002b).  The suitable water velocity range for spawning coho salmon reportedly is 0.98 to 2.99 ft/sec (0.3 to 0.9 m/sec) (Bjornn and Reiser 1991).	
Depth range for spawning	Water depth range the fish can spawn.	In California, coho salmon reportedly spawn in streams at water depths of 0.3 to 1.8 feet (0.1 to 0.54 meters) (Hassler 1987).  Coho salmon reportedly spawn mostly in small streams where stream depth ranges between 4 to	

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		14 inches (10.2 to 35.6 centimeters) (DFG 2002b).	
Depth preference for spawning	Optimal water depth for spawning.	For migrating and spawning adult coho salmon, the reported suitable water depth range is 4 to 7.9 inches (10.2 to 20.1 centimeters) (Bjornn and Reiser 1991).	
Range for spawning timing	Earliest and latest time of season or year they spawn.	In California, coho salmon reportedly spawn between November and March (Weitkamp et al. 1995).	
Peak spawning timing	Time of year most fish start to spawn.	Coho salmon spawning reportedly usually peaks from November to January (Hassler 1987; Shapovalov and Taft 1954; Weitkamp et al. 1995).	
Spawning frequency (iteroparous/semelparous)	Semelparous - producing all offspring at one time, such as in most salmon. Usually these fish die after reproduction. Iteroparous - producing offspring in successive, e.g., annual or seasonal batches, as is the case in most fishes.	Coho salmon are semelparous spawners. Coho salmon die after spawning (Sandercock 1991).	
<b>Incubation/Early Development</b>			
Egg characteristics	Shape, size, color, in clusters or individuals, stickiness, and other physical attributes.	Coho salmon eggs are large, orange-red, and demersal. Reported egg diameters range from 0.18 to 0.2 inches (4.5 to 6.0 mm). However, an average diameter of 0.3 inches (7.2 mm) was derived from the data published by Shapovalov and Taft (1954) (Hassler 1987).	
Water temperatures tolerated for incubation	Temperature extremes at which eggs can survive incubation.	Coho salmon embryos reportedly sustained 50% mortality at water temperatures above 56.3°F (13.5°C) (DFG 2002b).	
Preferred range of water temperatures for incubation	Optimum temperature range for incubation.	In hatcheries, coho salmon eggs reportedly hatched in about 38 and 48 days at water temperatures of 51.8°F and 48.2°F (11°C and 9°C), respectively (Hassler 1987).  Coho salmon eggs reportedly hatch in 68 to 101 days at a water temperature of 40.1°F (4.5°C) (Hassler 1987).	
Time required for incubation	Time duration from fertilization to hatching. Note: Indicate at which temperature range. Incubation time is temperature-dependent.	Coho salmon embryos reportedly hatch after 8 to 12 weeks of incubation (Sandercock 1991).  In Waddell Creek, California, coho salmon eggs	

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		usually hatched in 35 to 50 days (Shapovalov and Taft 1954).  In hatcheries, coho salmon eggs reportedly hatched in about 38 and 48 days at water temperatures of 51.8°F and 48.2°F (11°C and 9°C), respectively (Hassler 1987).  Coho salmon eggs reportedly hatch in 68 to 101 days at a water temperature of 40.1°F (4.5°C) (Hassler 1987).	
Size of newly hatched larvae	Average size of newly hatched larvae (in mm).	Newly hatched coho salmon larvae in Margaret Creek, Alaska reportedly averaged 1.3 to 2.4 inches (32 to 60 mm) (Bryant et al. 1996).  Newly hatched coho salmon larvae in Lake Erie reportedly weighed 0.005 to 0.01 ounces (0.146 to 0.283 grams) (Leatherland et al. 1989).	
Time newly hatched larvae remain in gravel	Time of year hatching and duration between hatching and emergence from gravel.	Coho salmon hatchlings reportedly remain in the gravel until their yolk sac has been absorbed, 4 to 10 weeks after hatching (Sandercock 1991).  Coho salmon larvae reportedly start emerging from the gravel 2 to 3 weeks after hatching, and continue to emerge for an additional 2 to 7 weeks (Hassler 1987).	
Other characteristics of alevins	Alevin -- early life history phase just after hatching (larva) when sac still present.	Yolk-sac coho salmon larvae reportedly remain in the gravel for several weeks while they are nourished by the yolk; the larvae reportedly are initially photonegative, but become photopositive as they approach emergence (Hassler 1987).  Laboratory observations suggest that the pituitary gland-thyroid tissue axis (PTA) is reportedly present in coho salmon before they hatch, but does become fully functional until after the yolk is absorbed (Leatherland and Barrett 1993).	
Timing range for emergence	Time of year (earliest-latest) hatchlings (alevins and fry) leave or emerge from the nesting/hatching	Coho salmon fry reportedly emerge from the gravel at night from March to May (Shapovalov and Taft 1954).	

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Element	Element Descriptor	General	Feather River Specific
	(gravel) sites.	Coho salmon eggs reportedly incubate in the spawning gravel in the Snohomish River watershed, Washington, through the winter and emerge as fry in March through May (Pess et al. 2002).	
Timing peak for emergence	Time of year most hatchlings emerge.	Coho salmon reportedly emerge from the gravel 46 to 48 days after they hatch (Leatherland et al. 1989).  Coho salmon larvae reportedly start emerging from the gravel 2 to 3 weeks after hatching, and continue to emerge for an additional 2 to 7 weeks (Hassler 1987).	
Size at emergence from gravel	Average size of hatchlings at time of emergence.	Average size of coho salmon at release from the Puyallup River Salmon Hatchery reportedly was 0.1 ounces (1.88 g) in 1982 and 0.03 ounces (0.75 g) in 1983 (Bilby and Bisson 1987).	
<b>Juvenile Rearing (In Freshwater)</b>			
General rearing habitat and strategies	General description of freshwater environment and rearing behavior.	Juvenile coho salmon reportedly are generally at highest densities in deep, cool pools with plenty of overhead cover, especially in summer. Juvenile coho salmon reportedly use a wide variety of habitats if cover, depths, temperature, and velocities are appropriate. Juvenile coho salmon reportedly are associated with instream cover close to areas that are productive for feeding (Moyle 2002).  Juvenile coho salmon reportedly show pronounced shifts in habitat with season, especially in California streams. In winter, juvenile coho reportedly select habitats with low water velocity such as alcoves, side channels, backwater ponds, beaver ponds, riverine ponds, and deep rootwad-formed pools for protection against predators and high discharge (Bell et al. 2001).  In spring when stream flows are moderate and fish are small, juvenile coho salmon reportedly are widely distributed through riffles, runs, and pools. As stream flows diminish in summer, juvenile coho salmon reportedly increasingly concentrate in pools	

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Matrix Of Life History and Habitat Requirements for Feather River Fish Species – Coho Salmon  
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Element	Element Descriptor	General	Feather River Specific
		<p>or deeper runs. During winter, before emigration, juvenile coho salmon reportedly seek refuges from high velocity flows generated by winter storms (Moyle 2002).</p> <p>Juvenile coho salmon reportedly rear in cool tributaries, in contrast with Chinook which stay in warmer main rivers (Moyle 2002).</p>	
Water temperatures tolerated by rearing juveniles	Extreme water temperatures rearing juveniles can survive. Indicate whether these extremes are stress or lethal levels.	<p>Juvenile coho salmon reportedly do not persist in streams where summer water temperatures reach 71.6°F to 77°F (22°C to 25°C) (Hassler 1987).</p> <p>In the Mattole River (Humboldt and Mendocino Counties), coho salmon reportedly are absent from tributaries in which the maximum water temperature exceeded 64.4°F (18°C) for more than a week, suggesting that threshold for persistence may be lower than once thought (Welsh et al. 2001).</p> <p>Water temperatures exceeding 77°F to 78.8°F (25°C to 26°C) are reportedly lethal to coho salmon (Moyle 2002).</p> <p>Water temperature within the subbasin of Coos Bay, where juvenile coho salmon are found, reportedly ranges from 42.8°F to 60.8°F (6°C to 16°C) (Miller and Sadro 2003).</p>	
Water temperature preferred for rearing	Optimum temperature range for rearing juveniles for growth.	<p>In laboratory tank experiments under controlled conditions, preferred water temperatures of juvenile coho salmon acclimated at 41°F, 50°F, 59°F, 68°F, and 73.4°F (5°C, 10°C, 15°C, 20°C, and 23°C) were reported to be in the range of 53.6°F to 57.2°F (12°C to 14°C) (Brett 1952; Welsh et al. 2001).</p> <p>Juvenile coho salmon reportedly prefer and presumably grow best at water temperatures of 53.6°F to 57.2°F (12°C to 14°C) (Moyle 2002).</p> <p>In the summertime, coho salmon fry reportedly prefer water temperatures of 50°F to 59°F (10°C to</p>	

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Matrix Of Life History and Habitat Requirements for Feather River Fish Species – Coho Salmon  
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Element	Element Descriptor	General	Feather River Specific
		15°C) (Reiser and Bjornn 1979).	
Velocity ranges for rearing juveniles	Minimum and maximum water velocities (flows and currents) the rearing juveniles can tolerate.	Water velocities within the Onion River, Wisconsin, where juvenile coho salmon were found, reportedly ranged from 0 to 31.5 in/sec (0 to 80 cm/sec) (mean = 5.9 in/sec [15 cm/s]) (Healy and Lonzarich 2000).  Mean monthly discharge within the subbasin of the Coos Bay, where juvenile coho salmon are found, reportedly ranges from less than 0.2 ft <sup>3</sup> /sec (0.05 m <sup>3</sup> /sec) during the summer to over 18.7 ft <sup>3</sup> /sec (5.7 m <sup>3</sup> /s) during the winter (Miller and Sadro 2003).	
Velocities preferred by rearing juveniles	Optimum range of water velocities for rearing juveniles.	Preferred water velocities for juvenile coho salmon reportedly are 0.3 to 1.5 ft/sec (0.09 to 0.46 m/sec). Juvenile coho salmon will reportedly actively seek refuges from high velocities (Moyle 2002).  The suitable water velocity range for rearing juvenile coho salmon reportedly is 0.16 to 1.28 ft/sec (0.05 to 0.4 m/sec) (Bjornn and Reiser 1991).	
Cover preferences for rearing juveniles	Type of cover for protection from predator used by rearing juveniles (e.g., crevices, submerged aquatic vegetation, overhanging vegetation, substrate cover, undercover bank, small woody debris, large woody debris).	Juvenile coho salmon reportedly are generally at highest densities in deep ( $\geq 1$ m), cool pools with plenty of overhead cover. Juvenile coho salmon are typically associated with instream cover such as undercut banks, logs, and other woody debris (Moyle 2002).  As coho salmon fry grow, they reportedly stay in relatively deep pools with overhanging logs (Shapovalov and Taft 1954).  In summer, coho salmon fry reportedly prefer a mixture of different types of riffles and pools with large woody debris, undercut banks, and overhanging vegetation (Reiser and Bjornn 1979).	
Food base of juveniles	Indicate primary diet components, i.e. what they eat. Also indicate the diet changes, if any, as they grow.	The diet of juvenile coho salmon reportedly consists mainly of aquatic insect larvae and terrestrial insects. Small fish are reportedly also consumed by juvenile coho salmon when available. When adults are spawning, loose eggs and fragments of decaying carcasses reportedly can also be major	

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Element	Element Descriptor	General	Feather River Specific
		food items especially when other food is scarce (Moyle 2002).	
Feeding habits of rearing juveniles	Indicate: Plankton eaters, bottom feeders, piscivorous, active hunters, ambush predators, filter feeders. Night, day, dusk or dawn feeders. Also indicate change of feeding habits as they grow.	In streams, juvenile coho salmon reportedly can be voracious feeders, ingesting any organism that moves or drifts over their rearing area. Peaks of feeding are typically at dawn and dusk, when drifting insects are most available, but daytime feeding on abundant prey is also common (Moyle 2002).	
Predation of juveniles	Indicate which species prey on juveniles.	In west coast areas, coho salmon are reportedly attacked by lampreys and preyed on by larger coho, cutthroat trout, steelhead, Dolly Varden, pikeminnows, and sculpins (Hassler 1987).	
Timing range for juvenile rearing	Range of time of year (months) during which in-river rearing occurs.	Juvenile coho salmon reportedly rear year-round (12 to 24 months) before they migrate as smolts (Moyle 2002).  Coho salmon that move to the ecotone of Winchester Creek during spring reportedly may live within this reach for up to 8 months (March through October); during summer, 62.6% of fish reportedly ascended to Winchester Creek to overwinter and did not re-enter the estuary until spring as age-1 migrants (Miller and Sadro 2003).	
Timing peak for juvenile rearing	Time of year (months) during which most in-river rearing occurs.	In the Taku River and estuary in Alaska, Murphy et al. (1997) reportedly found peak coho salmon smolt abundance in the river to occur in late May (Miller and Sadro 2003).	
<b>Juvenile Emigration</b>			
Time spent in fresh water prior to emigrating	Duration (in years and/or months) from emergence to emigration to the ocean.	Most coho salmon smolts leaving California streams reportedly are 12 to 15 months old. Some juveniles reportedly stay in the stream 2 years before emigration (Moyle 2002).  Most coho salmon reportedly migrate to the ocean about a year after they emerge from the gravel (Shapovalov and Taft 1954).	
Water temperature tolerances during emigration	Temperature range during emigration the juveniles can survive. Indicate stress and lethal levels.	Coho salmon have reportedly been observed emigrating through Klamath River estuary when the water temperature ranged from 53.6°F to 68°F (12°C to 20°C) (DFG 2002b).	

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Element	Element Descriptor	General	Feather River Specific
		Coho salmon reportedly have been observed throughout their range to emigrate at water temperatures ranging from 36.6°F to 56°F (2.6°C to 13.3°C) (Sandercock 1991).	
Water temperature preferences during emigration	Optimum temperature range for juveniles during emigration.	Average diurnal water temperature during coho salmon emigration in the clear cut stream reportedly was 38.1°F to 40.5°F (3.4°C to 4.7°C) and was 32.9°F to 34.4°F (0.5°C to 1.3°C) in the old growth stream of the Deschutes River system (Bilby and Bisson 1987).	
Emigration timing range	Time of year juveniles commence emigration and duration of emigration.	Coho salmon emigration from streams in California reportedly takes place in March, April, and May (Moyle 2002).  Smolt outmigration of California coho salmon stocks reportedly occurred between mid-March to early August (Weitkamp et al. 1995).	
Emigration timing peak	Time of year most juveniles are emigrating.	Coho salmon emigration reportedly typically peaks from late April to mid-May (Moyle 2002; Shapovalov and Taft 1954).  Peak coho salmon outmigration reportedly occurs in May, and with smolts measuring 3.5 to 4.5 inches (90 to 115 mm) FL (Weitkamp et al. 1995).	
Size range of juveniles during emigration	Minimum and maximum sizes (mm or centimeters) of emigrating juveniles. Indicate average size.	The coho salmon emigrants reportedly are mostly 1 year olds and measure 3.9 to 5.1 inches (10 to 13 centimeters) FL. A few larger 2-year-olds reportedly may also be present (Moyle 2002).  Coho salmon smolts leaving California streams as “yearlings” (12 to 15 months old) reportedly measure 3.1 to 5.9 inches (8 to 15 centimeters) FL (Moyle 2002).  The size range of most migrating coho salmon reportedly is 4.1 to 4.6 inches (103 to 117 mm) (Shapovalov and Taft 1954).  Peak coho salmon outmigration reportedly occurs in	

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Element	Element Descriptor	General	Feather River Specific
		May, and with smolts reportedly measuring 3.5 to 4.5 inches (90 to 115 mm) FL (Weitkamp et al. 1995).	
<b>Other Potential Factors</b>			
DO	Levels of dissolved oxygen in water expressed in mg/l tolerated by fish (lower limits).	<p>Holding coho salmon require near-saturation levels of dissolved oxygen especially in fast-moving waters (Hassler 1987).</p> <p>In Waddell Creek, California, oxygen saturation reportedly was usually above 85% during adult coho salmon migration (Shapovalov and Taft 1954).</p> <p>For migrating coho salmon adults, the reported suitable range of DO is 80% saturation and &gt;0.037 ounces/gallon. Rearing coho salmon juveniles reportedly prefer 100% DO saturation; DO levels of 0.37 to 0.44 ounces/gal are reportedly stressful, while DO levels &gt;0.59 ounces/gallon are reportedly considered optimum. For coho salmon eggs and fry, nearly complete DO saturation is reportedly preferred and &gt;0.59 ounces/gallon is reportedly optimum (Bjornn and Reiser 1991).</p>	
pH	Alkalinity/acidity of water (expressed in pH) that fish can tolerate.	Under laboratory conditions, coho salmon were reportedly observed to tolerate a pH range of 6.1 to 8.2 (Dahlberg et al. 1968).	
Turbidity	Indicate: level or turbidity or state of water (e.g., clear water or presence of siltation or organic/inorganic matter in water) that fish can tolerate	<p>Typical coho salmon rearing streams are very clear. Even moderate silt loads can damage the gills of small coho salmon and reduce growth rates. Short periods of high turbidity or silt loads reportedly can be detrimental to emergence, feeding, and growth of young coho salmon (Hassler 1987).</p> <p>Streams with turbidities of &lt; 25 mg/L provide reportedly provide “good” coho salmon habitat (Reiser and Bjornn 1979).</p> <p>Prolonged exposure to high turbid water reportedly may cause thickening of gill lamellae, clogging of gills, and curtailment of feeding in coho salmon (Reiser and Bjornn 1979).</p>	

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Element	Element Descriptor	General	Feather River Specific
		Coho salmon fry (30 to 65 mm long) subjected to chronic turbidities of 25 to 50 mg/L reportedly showed gill tissue damage after 3 to 5 days exposure (Hassler 1987).	
Factors contributing to mortality/survival	Indicate causes of mortality to fish (e.g., fishing/angling mortality, drastic habitat alterations, abiotic factors, unfavorable climatic changes, etc.).	<p>Brown et al. (1994) discussed the reasons for the decline of coho salmon in California. The reasons reportedly include:</p> <ul style="list-style-type: none"> <li>• Stream alterations brought about by poor land practices (especially those related to logging and urbanization) and by the effects of periodic floods and drought</li> <li>• The breakdown of genetic integrity</li> <li>• Introduced diseases</li> <li>• Overharvest</li> <li>• Climatic change</li> </ul>	
General passage considerations (upstream and downstream)	Indicate issues associated with fish passage (e.g. burst speed, max speed, handling stress, survival rates, stressors, body type, etc.).	<p>Stressed coho salmon (taken out of water and forced to struggle for 5 minutes) reportedly showed marked increases in adrenaline and suffered from exhaustion, as noted in a laboratory study (Mazeaud et al. 1977).</p> <p>Wydemeyer (1972) showed that in coho salmon and steelhead fingerlings, 3 ppt salt concentrations in water alleviated stress of handling (as measured by blood chemistry) for fish transported in the Columbia-Snake River system (Monk et al. 1989).</p> <p>In laboratory studies, transportation reportedly reduced the coho salmon's ability to survive a 2nd stress of crowding confinement (Specker and Schreck 1980 <i>in</i> Sigismondi and Weber 1988).</p> <p>Transportation reportedly reduced the ability of coho salmon smolts to tolerate the stressing agent of severe and prolonged crowding (Specker and Schreck 1980).</p> <p>Laboratory studies using strobe lights have reportedly shown an effective range of 19.7 feet (6</p>	

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Element	Element Descriptor	General	Feather River Specific
		<p>meters) for juvenile coho salmon under low ambient lighting (Ploskey and Johnson 1998; Ploskey et al. 1998); this range is reportedly sufficient to prevent entrainment at most sites (also need to consider other factors present) (Mueller et al. 2001).</p> <p>Coho salmon distribution patterns were reportedly greatly altered by strobe light treatments before and during daytime fill events at the Lower Granite Dam on the Snake River (Johnson et al. 2001).</p> <p>Strobe lights were reportedly shown to effectively clear the immediate area in front of the culvert entrance of fish at the Lower Granite Dam on the Snake River (Johnson et al. 2001).</p> <p>Studies reportedly found that yearling coho salmon guidance was significantly higher with bar screens than with submersible traveling screens at the Bonneville Dam on the Columbia River (Gessel et al. 1991).</p> <p>Behavioral changes associated with coho salmon smolt development reportedly influences fish guidance (Gessel et al. 1991).</p> <p>Damage from spillways reportedly occurs to the coho salmon gills, eyes, and internal organs and can occur when the impact velocity to fish on the water surface in downstream pools exceeds 52.5 ft/sec (16 m/sec) as noted within the Columbia River basin (Bell &amp; Delacy 1972 in Larinier 2000).</p> <p>Beyond a drop of 42.7 feet (13 meters) injuries may become significant and mortality increases rapidly for fish as noted within the Columbia River basin (Larinier 2000).</p> <p>Salmonids reportedly had an increase in percentages of passage at the submerged orifices</p>	

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Element	Element Descriptor	General	Feather River Specific
		<p>than at either the shallow orifices or slots at John Daly Dam on the Columbia River (Monk et al. 1989).</p> <p>Efforts made to minimize stress for coho smolts in Baker Lake, Washington include:</p> <ul style="list-style-type: none"> <li>• Holding fish before and after tagging in covered flow-through containers</li> <li>• Using isotonic solution during recovery and transport</li> <li>• Water-to-water transfer of fish</li> <li>• Releasing fish near Sunset</li> <li>• Acclimating study fish at release time for holding vessels to the reservoir (Puget Sound Energy 2002)</li> </ul> <p>The Lake Merwin Fish Collector reportedly improved efficiency in 1964 due to lead and walls that extended below the 28-foot maximum fishing depth (CH2M Hill 1980).</p>	

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